PROJECT-X1 xx1 Test Analysis Report

July 2004

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1. Executive Summary

This report documents the IV&V Team's test analysis findings and recommendations on the PROJECT-X1 Build Tests, Formal Qualification Tests (FQTs), and the Payload Verification Test (PVT). The individual tests issues communicated by the IV&V Team to the project are captured within the Project Issue Tracking System's (PITS) Technical Issue Memorandums (TIMs). Details of the PITS TIMs are captured within Appendix A, TIMs Detailed Report.

1.1. Findings

The IV&V Team's test analysis findings are categorized into the following three test areas: Build Tests, Formal Qualification Tests (FQTs), and the Payload Verification Tests (PVTs).

1.1.1. Build Tests

IV&V does not have any significant findings for the build test analysis that was performed. Note that, Build Test Analysis was not intended to be a detailed analysis by the IV&V Team.

1.1.2. Formal Qualification Tests (FQTs)

The payload software FQT was an internal developer milestone that qualified the software to run on the flight hardware. The flight software is actually two separate releases, and a separate FQT was conducted for each release.

The Maintenance Operations Release (MOR) is the software that allows on orbit maintenance, including patching or replacing the Normal Operations Release (NOR). Activation of the MOR is controlled by the System X, which is outside of the IV&V scope. The MOR does not rely on any other payload software interfaces within IV&V's scope. Based upon the data provided to IV&V for analysis the MOR has a high probability of having been sufficiently tested and is not likely to fail any mission critical requirements. The artifacts analyzed by IV&V indicate the MOR testing verified it meets minimum mission success criteria, which provides a viable recovery path for any other software failures on orbit.

The Normal Operations Release (NOR) underwent two FQT rounds due to changes that had to be made in the software after the first was completed. IV&V was not provided with sufficient details of the 2nd FQT to perform analysis of that run. With the data provided, IV&V was able to verify that valid test procedures were mapped for all of the related NOR requirements, but IV&V needed insight into the "Test Language" (TL) procedure scripts to validate the tests were accurately implemented and the requirements were correctly and completely verified. Therefore IV&V cannot make a finding as to the sufficiency of this test, beyond the completeness of the mapping.

There were also FQT tests planed for System X components. IV&V was able to review the traceability matrix for the X Operations Control Center (XOCC). Again the information provided only confirmed the mapping of requirements to valid tests. The sufficiency of the tests to verify the requirements was not possible to ascertain.

1.1.3. Payload Verification Test (PVT)

Initially there were three (2) PVTs scheduled to exercise the system hardware and software from end-to-end. The first one was not performed on an integrated payload due to the failure of the System X assembly during testing. The second PVT was conducted as a true end-to-end integrated system test. IV&V was provided with data for this test. The project has devoted significant resources to verifying the requirements traceability matrix for this test was correct.
IV&V has identified one risk PROJECT-X1-RMS1-101, which was written when there was no documentation indicating PVT (2) would test the fully integrated system.

1.2. Recommendations / Lessons Learned

1.2.1. General

IV&V recommends that projects use an automated tool specifically designed to configuration manage the requirements for a project. When testing begins it is imperative that a controlled baseline set of requirements can be maintained. The PROJECT-X1 developer had recurrent problems with test traceability and design due to problems with maintaining the requirements baseline.

Test procedures need to have clearly established expected results, and should have an automated mechanism for collecting the actual results and comparing them with those expected so the test can determine its own completion status.

IV&V needs to be in direct contact with the Developer and must have access to appropriate artifacts to maximize return. IV&V cannot identify problems when the artifacts examined are too abstract from the development.

End-To-end testing plans and procedures are as important as the FQT and should be delivered well ahead of the testing so that analysis can be performed and results provided in a timely manor, while it is still possible to make changes.

1.2.2. Specific

The volume of data that must be analyzed to verify sufficiency and correctness of end-to-end testing cannot be processed prior to the Pre-Ship Review. If the analysis done to that point indicates that the testing was not flawed, then the analysis should continue after shipment until completed. If any deficiencies are identified they could be retested in the xx. If results indicate a potential problem, arrangements could be made to correct it before launch. The xx testing would not be as conclusive as the actual hardware, but it would mitigate the risk of a completely untested feature.

2. Introduction

2.1. Scope

This report documents the IV&V Team's test analysis findings and recommendations on the PROJECT-X1 Build Tests, FQTs, and PVT.

2.2. Overview

Section 3 discusses the 3 areas of software test analysis:

1. Build Test Analysis
2. Formal Qualification Tests (FQT) Test Analysis
3. Payload Verification Test (PVT) Analysis

Details of the PITS TIMs are captured within Appendix A, TIMs Detailed Report.

3. IV&V Software Test Analysis

The IV&V Team performed test analysis on the PROJECT-X1 Build Tests, FQTs, and PVTs. Specific analysis targeted for each of these test programs is described in the following sections.

The overall objectives, and associated tasks, for each type of test analysis are:

- Analyze System level verification requirements to verify that test definition, objectives, plans and acceptance criteria are sufficient to validate system requirements and operational needs.
- Verify Software Test Plan qualification testing methods and plans are sufficient to validate software requirements and operational needs
- Verify test cases traceability and coverage of software requirements, operational needs, and capabilities
- Verify software test development test case definition inputs, expected results, and evaluation criteria comply with software test plans plan and testing objectives
- Analyze correct disposition of software test anomalies
- Validate software test results compliance with test acceptance criteria
- Verify trace and successful completion of all software test case objectives
- Verify ability of software test environment plans and designs to meet software testing objectives
- Verify regression tests are sufficient to determine that the software is not adversely affected by changes

The IV&V Team used test plans, procedures and reports as detailed below to perform this analysis.

The IV&V Team documented intermediate results in PITS and/or on project specific comment forms, and coordinated resolution of the issues with the PROJECT-X1 Project. Details of the PITS TIMs are captured within Appendix A, TIMs Detailed Report.

3.1.1. Build Test Analysis

The IV&V Team verified build test coverage by tracing design/code to build tests and identify missing, incomplete build test coverage. The IV&V Team also checked test compliance and completion. The following table lists the TIMs associated with build test analysis and a brief summary of the issues.

Table 3.1.1-1: **Build Test Analysis Issues**

TIM ID	Requirement Issue	Final TIM State
PROJECT-X1 - TIM - 0001	Non-traceable test case in xx1	Closed
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[REMOVED]		

3.1.2. FQT Test Analysis

The IV&V Team verified that the FQT test plans were sufficient to V&V the software requirements. This was accomplished by verifying traceability from requirements to tests and identifying incomplete test coverage. The IV&V Team also verified that test definitions and acceptance criteria were sufficient to verify software requirements.

In addition to previously completed analysis results, the IV&V Team used the following documents to perform this analysis:

- FQT Test Plans and Procedures
- PROJECT-X1 Program test traceability matrices
- FQT Test Plans and Procedures
- Build Test Plans, Procedures and Test Reports
- xx1

The following table lists the TIMs associated with FQT test analysis and a brief summary of the issues.

Table 3.1.2-1: **FQT Test Analysis Issues**

TIM ID	FQT Test Analysis Issue	Final TIM State
PROJECT-X1 - TIM – 0056	Xx1 procedures implements FQT test procedure incorrectly	Closed
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[REMOVED]		

3.1.3. Payload Verification Test Analysis

IV&V was not provided with sufficient data to verify or validate a true end-to-end PVT on the actual fully assembled flight hardware. IV&V believes it is possible that post shipment defects

will be discovered during integration with the platform if thorough end-to-end PVT testing is not completed.

The following risk was generated regarding this end to end test issue:

<table>
<tr><td></td><td>PROJECT-X1-RMS-109</td><td>Level =Medium</td></tr>
<tr><td>Title</td><td colspan="2">End to End testing may not be sufficient to mitigate risk of post shipment anomalies</td></tr>
<tr><td>Description</td><td colspan="2">The current test plans that have been reviewed by IV&V do not present any evidence that there is a true End to End full system test on the actual fully assembled flight hardware planned prior to shipment to France.

[REMOVED]</td></tr>
<tr><td>Mitigation</td><td colspan="2">[REMOVED]</td></tr>
<tr><td>IV&V Comments</td><td colspan="2">--</td></tr>
<tr><td>Resolution Chronology</td><td colspan="2"><table><tr><th>Date</th><th>Entries</th></tr><tr><td>01/22/2004</td><td>After discussions with the project software management ..

[REMOVED]</td></tr></table></td></tr>
</table>

Appendix A - TIMs Detailed Report

PROJECT-X1 - TIM - 1317
Subject: xx1 Requirement Issues

Description:

Location	*Comment*
Section 9.1	It is suggested that add the phrase "…." to the end of the xx1 requirements definition.
2.5.3 Test Case: Invalid xx1 Processing	[REMOVED]
General	--
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[REMOVED]	

PROJECT-X1 - TIM - 1218
Subject: xx1 Verification Procedures Issues

Description:

Location	*Comment*
2.6.1.4	Step #15 refers to an invalid "…"
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[REMOVED]	

PROJECT-X1 - TIM - 1318

Subject: xx1 Requirements Verification Matrix Test Case Issues

Description:

[REMOVED]